ELECTRICITY AND LIFE:

OR,

THE ELECTRO-VITAL THEORY OF NATURE.

BY

EDWARD C. TOWNE, B.A.

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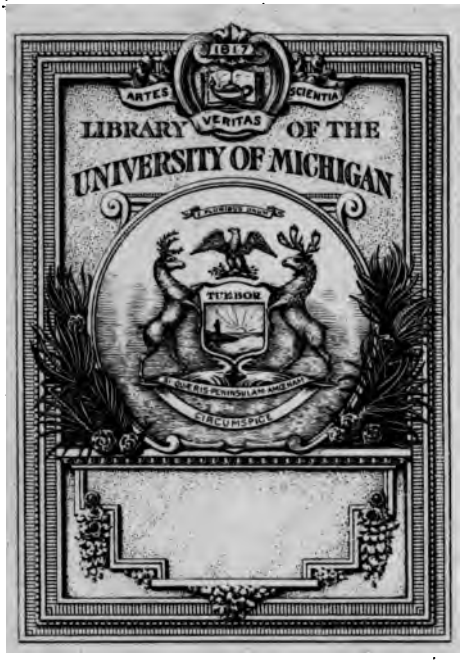
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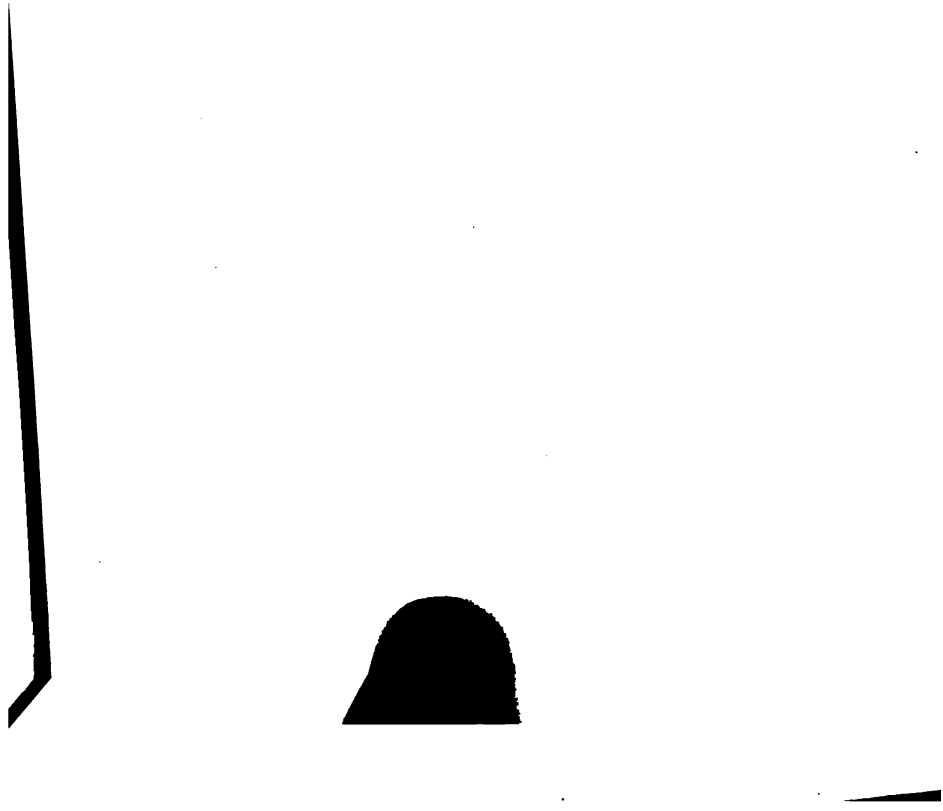

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PREFATORY.

THESE pages are designed to present a summary statement of the main points of a new system of nature, or natural history of creation; not embracing minor points involved, and not to any adequate extent indicating the evidence of admitted facts, the consent of high authorities in science, and the course of reasoning, on which the author's conclusions are based, and for a full view of which he refers to the large work of elaborate research and comprehensive exposition and discussion, which will be published under the title: —

ELECTRICITY AND LIFE, OR THE ELECTRO-VITAL THEORY OF NATURE: A TREATISE ON THE ELECTRICAL FUNCTION OF THE OXYGEN OF RESPIRATION, AND THE ELECTRICAL CAUSES OF LIFE, FUNCTION, STRUCTURE, AND SPECIES.

There will be set forth in this Treatise a complete view of the electrical character of animation or vitality in both animals and plants; the making and maintenance and operation of all function and structure in living things by electrical agency introduced through the oxygen of respiration; and the origin of variations and true origin of species, and evolutionary ascent of the creation, not by means of natural selection, but upon a method of natural creation which results from the electrical conditions of all living forms, and which makes evolution vastly easier and quicker and surer than upon the Darwinian hypotheses.

If the hypothesis on which the whole research turns, that of *the electrical function of the oxygen of respiration*, is accepted, it introduces an amount of new knowledge never before reached in a single stage of research, if indeed it does not contribute to biology and to medical science more than all that has gone before, at once solving the problem of vitality, establishing the

true method of creation in nature, and replacing the Darwinian with a vastly more rational view of the origin of species and the basis of evolution; and under these chief heads dealing with a long list of unanswered questions, or questions wrongly answered, never before brought within a single course of inquiry, — such as the nature of electricity; the enormous amount of it connected with the atoms of common matter, as Faraday long since abundantly taught and Helmholtz has lately maintained; the exceptionally electrical character of oxygen and its universal function in nature; the electrical character of ordinary combustion and of our common lights; the method of plant life as well as of animal by breathing electricity in oxygen-atom doses; the introduction into protoplasm or living matter of the vital state and vital motion by the electrical driving in of oxygen; the electrical initiation and maintenance of everything done or made in living things through the oxygen of respiration; the construction of the animal and vegetable cell, and upward from that of all animal and plant structure, by electrical handling of the electrically animated matter; the electrical making of the character-bearing reproductive germ; the dual character of all animal and plant organisms, through the union of reproductive germs; the cause and method of the wonderful segmentation and development of the dual germ with which animal development begins, and from that upward the cause and method, always electrical or magnetic, of muscular contraction and nervous impulse; the electrical making, in fact, and operation, of muscle and nerve, body and brain, and every form of function and energy; the creative operation of environment acting through parent organisms on the reproductive germs of plant or animal, or on the animal embryo, electrically conditioned and thus responsive to every efficient influence or pressure, in ways infinitely productive of variation, of specific change, and of the evolution and ascent of the creation; and thereby the miracle of man pushed up to the height of intelligent mind, marvellous brain and form, genius and thought and eternal hope, from an animal below the human level, with none of the difficulty, the delay, and the enormously doubtful means of the Darwinian system.

The fruits of thought which are thus set forth discover to

science and to philanthropy the three greatest and most important facts in the entire system of nature: first, the electrical making and maintenance of the vital state through the medium of the oxygen of respiration; second, the establishment of function and the making of corresponding structure by means of the natural play of electrical and magnetic force within animated matter; and third, the origin of variations, the true origin of species, and the evolutionary ascent of the creation, not according to the Darwinian conceptions of natural selection, sexual selection, struggle for existence, and survival of the fittest, but by means of creative parentage, especially creative motherhood, or the influence of the environment, through the parent forms, upon electrically conditioned reproductive germs or embryonic forms.

It enters into the truth about species to show that reproductive germs are electrically, though not by set and fixed form, *patterns;* that each germ, male as well as female, acts as a reproductive structure, all animals and all plants (with some very low exceptions) being *two* woven into one, — the explanation of a vast range of facts which Darwinism has put in a wrong light; and that the distinction of sex results from electrical opposition of positive and negative. That insects have made the irregularities of the flowers which they visit; that cross-fertilization is Nature's better method, because only by it is adequate electrical opposition brought into play, and also because the two plants which are woven into one so often fail to develop evenly; and that insects greatly help by their electrical intensity, are conclusions immediately resulting from the main doctrine of the true origin of species. It may be remarked also that the incessant reference made by Mr. Darwin to *purpose*, which allowed the old supernaturalism to survive through a large part of his system, disappears altogether with the new doctrine, which knows only natural result, irrespective of immediate design. Darwinism borrows the Maker of heaven and earth for the original speck of protoplasm, and beyond that knows no God; but of little gods in the slime and the bush it is full. These do not belong in a true system of nature, which at once completes materialism, and gives it a cosmic elevation and breadth suggestive of Infinite Reason in the inscrutable background of natural law.

"Chemistry and magnetism have successively acknowledged the overruling influence of electricity; and it is probable that every effect depending upon the powers of inorganic matter, and perhaps most of those relating to vegetable and animal life, will ultimately be found subordinate to it."

"There is an immensity of facts which justify us in believing that the atoms of matter are in some way endowed or associated with electrical powers, to which they owe their most striking qualities. . . . It is wonderful to observe how small a quantity of a compound body is decomposed by a certain portion of electricity. *One grain* of water will require an electric current equal to a very powerful flash of lightning. . . . This gives an almost overwhelming idea of the extraordinary quantity or degree of electric power which naturally belongs to the particles of matter — the enormous electric power of each particle or atom of matter."

"Magnetic action may be considered as a mere function of electric force."

"Oxygen appears to be a very magnetic substance. . . . The magnetic properties and relations of oxygen are perfectly clear and distinct, and are established by experiment. . . . The attraction of iron filings to a magnetic pole is not more striking than the appearance presented by the oxygen, . . . passing with great impetuosity to the magnetic axis, and clinging about it. . . . The magnetic constitution of oxygen seems to me wonderful. It is in the air what iron is in the earth. . . . In nature it stands in this respect, as in all its chemical actions, alone. . . . One can scarcely think upon the subject of atmospheric [oxygenic] magnetism without having another great question suggested to the mind. What is the final purpose in nature of this magnetic condition of [the oxygen of] the atmosphere, and its entire loss by entering into combination either in combustion or respiration? No doubt there is one or more, for nothing is superfluous there." — FARADAY: *Experimental Researches in Electricity.*

ELECTRICITY AND LIFE;

OR,

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"PROTOCOCCUS," says Professor Huxley, "retains its vitality after it has been dried. It has been preserved for as long as two years in the dry condition, and at the end of that time has resumed its full activity when placed in water."

Is it credible that a plant dried to a mummy for two years should be still alive; evidently dead, and yet alive; or that, being dead, or dead and alive, it should of itself rise from the dead when placed in water? There is no scientific evidence that the microscopic mummy retains any vitality whatever, or that resumption of activity results from any power or property retained by said mummy. The fact that such statements can be made, plainly without reason and against reason, is conclusive proof that a wholly false idea of vitality is made use of, an idea which is a survival from pre-scientific biology. Science must give an explanation of vitality consistent with scientific observation and reason. And to get more into view the whole problem, we may cite another fact in the life of Protococcus. The mere microscopic globule may be observed to develop within itself a pair of spores, each of which develops a pair of very long thread-like tails, which are seen to writhe and lash about inside the parent globule. In strict science, we must ask for an explanation, not in scholastic terms like "vitality," "motility," and other ingenious names which convey no knowledge, but in terms of matter and motion and force, of the alive state which we observe, of the structure which we see set up, and of the movement so curiously carried on by this structure. How is the microscopic globule animated or made alive? How are the spores formed within it, each with its pair of thread-like tails? And how are these tails made to writhe and lash about inside the wall of the parent globule?

The answers given by our biological authorities cannot possibly be true. Professor Huxley says that in living things large piles of atoms

tumble down into small ones, and thereby set free energy. Professor Tyndall says that heat results, and causes the motions of life. No tumbling down could form two globules, each with two lashing tails, inside a parent globule, and the rapid lashing of these tails could not be due to heat. This microscopic globule, with its marvel of structure and of motion, is neither in a tumble nor in a heat, and we may say with confidence that the tumbling-down theory and the heat theory are no explanation whatever of the energy and the motions of life. Whoever will put theory and facts side by side can readily see that the facts are not in the least explained. The stream of energy, the formation of structure, and the movements involved in living action are not accounted for. A little delusive rhetoric, about the engine and the lamp of life, is all that we get. When engines go by rusting and bodies by rotting down, or when, without steam-fixtures and steam, an engine can go by being heated a little, we may, if we can know no better, try to make something of the theory that chemistry and heat explain vitality. In fact, they afford no explanation at all.

Nor are we in the least helped to an explanation by anything that has been said about protoplasm. To say that life is due to the properties of protoplasm is to talk barren and delusive scholasticism, as far from science as it would be to say that a soap-bubble is expanded from a dull speck to a brilliant globe by the property of the soap film, or that the movement of a sailing vessel is due to the properties of the sails. The protoplasm is real, and it is essential; its properties, the result of chemistry, are genuine and necessary conditions; but having these, we require a cause of animation and vital motions corresponding to the air blown into the bubble and the wind pressing against the sail. Instead of, as Dr. Allman puts it, "every vital act being referable to some mode or property of protoplasm," we are bound to find in some adequate material source of motions the real explanation of the motions which constitute life.

It is illegitimate to say, as Professor Duncan does, that "the energies and powers of life are something which accompany carbon." The energies and powers of a sailing vessel accompany the sail, but *whence* are they? The energies and powers concerned in a blacksmith's work accompany the anvil, and the passive part played by the anvil is important, but the active doer of the work is not the anvil, but the smith. Protoplasm, carbon, play only a passive part. In combustion the carbon is the anvil, and the smith that strikes fire and light is the storm of oxygen atoms. The experiment with fine powder of iron, let to fall through the air, shows clearly that the oxygen atoms are clothed with attacking energy. The powder of iron falls passively, and as it falls becomes hot and glowing under the furious attack of

the oxygen atoms, and it is found that for a pound of iron powder nearly half a pound of oxygen atoms beat themselves into union with the iron atoms. The latter are as plainly as possible relatively inactive; the manifested activity is that of the oxygen atoms; they do the immediate work. As soon as we make the iron a powder, and by shaking it into the air separate the iron atoms so as to expose them fairly, the oxygen atoms make their intense attack, striking so fast and hard as to strike fire and light. The energy and power put forth belong to the oxygen atoms. If we take carbon in the form of diamond, and burn it, we can plainly see that the attacking energy is in the oxygen atoms. A certain amount of energy, or state of motion, must indeed be given to the carbon atoms, before the attacking energy of the oxygen can take effect, but it is relatively a very low degree, and only serves to get the carbon atoms apart from each other and into a state to be hit. When we apply the heat of a match-flame to a jet of hydrogen atoms, the effect is to just enough heighten their state of motion, and separation one from another, to give the oxygen atoms a chance to attack them. The attack of the oxygen causes the combustion. A striking experiment has been made the ground, by a recent work, for asserting that under the conditions of the experiment "oxygen is the burning body and hydrogen is the supporter of combustion." There is shown a jet of oxygen in a jar of hydrogen, and because the jet of flame produced cannot be distinguished to the eye from that produced by hydrogen burning in oxygen, we are asked to see oxygen burning in hydrogen. But the simple fact is that the oxygen can take the inside of the flame-jet just as well as the outside, and the arrangement affords no ground whatever for the incredible suggestion that the hydrogen and oxygen are made to exchange functions.

The function of oxygen is one of the most intense activity. One authority correctly says that "oxygen is an intensely active substance," yet proceeds to call the ordinary state of oxygen its passive state, and speaks of ozone as the active state of oxygen, ozone being oxygen concentrated or condensed. The Encyclopædia Britannica, in the article on "Electricity," also speaks of "oxygen in the active state as ozone," and calls ozone "the active form of the gas." The recent work of very high authority to which we have just referred has a section under the title "Ozone or Active Oxygen," and calls ozone also "the active variety of oxygen." The "ozone is formed when electric sparks are passed through perfectly dry oxygen gas," with such a change of bulk as to lead to the conclusion that "three volumes of oxygen condense to form two volumes of ozone." It is therefore said that "ozone is nothing more than condensed oxygen." Oxygen

in this state is said to possess "extremely energetic properties," and to be capable of "heightened oxidizing action." The common state can be restored, and the oxygen is then said to have "lost all its active properties" — a manifestly inaccurate statement. It is the extra energy peculiar to this state which disappears; the ordinary energy remains. The Encyclopædia article to which we have referred speaks of "excess of intrinsic energy," and "a state of greater intrinsic energy than usual," as found in hydrogen liberated by electrolysis. The oxygen liberated in the same way contains ozone, and the true account of the ozone is that it is oxygen in "a state of greater intrinsic energy than usual," oxygen with "excess of intrinsic energy." It should go almost without saying that in its ordinary state oxygen has a degree of remarkable activity, an intense energy, to be accurately and adequately known if we would understand the part which it plays in the composition of our globe, in the action of our fires, and in the animation of all living things. The thesis for which we believe all our knowledge compels us to contend is, that oxygen has made the world, substantially, by its part in the composition of the substances which form the globe; that its energy causes all combustion, and thus does all the work of our fires; and that it has made all living forms, of both animal and plant, and causes their animation and motions of life, and is entirely and absolutely the cause of every form and degree of vitality. The active endowment of the oxygen atom, the state of electrical charge in which it is, is the source of the motions by which the globe was made, of those which give us fire and artificial light, and of all motions of life. That is the contention which all plain facts compel us to undertake.

The plainest fact in the history of the globe is the place and work of oxygen. The plainest fact in our making of fire and light is the part played by oxygen. The plainest fact in regard to all living things is their dependence upon oxygen. Oxygen is the most abundant element in nature. It is the active element of common air. Its combinations with other elements form rock and earth and water, and make the globe. The oxygen that has gone into solid substances amounts to nearly one half the whole mass of the crust of the globe. The water of the globe is eight ninths oxygen. Fully one half of the weight of all minerals, three quarters of the weight of all animals, and four fifths of the weight of all vegetables, is oxygen. And all this means oxygen which has gone into the state of solid condensation, or of liquid, with the quenching of the energy which belongs to the atoms in the free state. The rule for any matter with which we have to do is nearly always that it has been made by oxygen atoms beating into union with other atoms. The crystalline rocks, which form the

chief mass of the earth's crust, and are nearly one half oxygen, may be said to be the compacted ashes of a burned-up mass of silicon and various metals. The burning up was done by the oxygen atoms, the incalculable attacking energy of which was quenched in the making of these rocks. In the same way the waters of the globe are the result of a like burning up of hydrogen atoms, done entirely by the energy of the oxygen atoms. The water, as well as the rock, represents the quenched energy of oxygen. And in all our fires the energy at work is that of oxygen, beating into union with fuel atoms. The smith is the oxygen atom; the fuel atom is the anvil on which the oxygen atom strikes. By a strange oversight our authorities ascribe the energy to the fuel, the comparatively passive element, instead of to the active and striking oxygen atom, the rebound of whose active energy gives us heat and light. The storm of oxygen atoms driving into our fires is the doer of all the work of these fires. It beats the immense block of iron into a state to be rolled. It sets in motion the engine which drives the vast ocean steamer. If we wish to strike a match, or to roll an armor-plate, or to melt a ton of iron, we call to our aid the oxygen atoms, and with doing a little ourselves they do all the rest. Their storm has a sureness, an intensity, an efficiency beyond all comparison. There is no like agent in nature, no substance active and working as oxygen is active and working.

And we can but ask ourselves the secret of the active energy of the oxygen atom. It is said to be chemical, but that is saying just nothing at all. Chemistry is the most incomplete of the sciences, from having done nothing to account for the effects which it enumerates and describes. It ought to go without saying that when oxygen atoms move with the most intense energy, it is because they are clothed with intense energy, for which we can give no explanation but that of *electrical* charge. They are intensely electric. We might infer this from the fact that if we apply electricity to oxygen in the ordinary state, the thus electricized oxygen proves to be only oxygen intensified in activity. Nature, then, gives us oxygen electricized to a degree, and a high degree, although not the highest possible. The fact that we can increase this degree conclusively proves that the oxygen atom is capable of electrical charge, and as the added charge augments oxidizing power we can clearly infer that ordinary oxidizing power is due to electrical charge. Sir Humphry Davy long since suggested that "chemical attraction is only a peculiar form of electrical attraction." It is an adequate explanation, and probable in the highest degree, while for no other explanation does our knowledge give us the least hint. The energy, then, of the oxygen atoms is electrical. By electricity the world was made, when oxygen atoms were driven into

holdfast union with atoms such as hydrogen to produce water; silicon and other elements to produce rocks. By electricity, too, is the work of our fires done. The old lights as much as the new are electric, only far less intense than the new. The oxygen storm beats upon the flame of our lights, and the fire of our engines, and the overflow or rebound of its electric energy produces those intense effects which we witness. If mere chemical union of atoms were accomplished, with no great overflow of intense energy, the effect of prodigious work done would not be possible. The chemical results are perhaps but incidental to the burst of physical energy with which the electrically charged oxygen atoms do their work.

And in view of this abounding and inexhaustible source of energy in the oxygen atoms, we may confidently expect to find in their electricity the secret of all vital motion and the vital state in the protoplasm of animals and plants. We find oxygen the supporter of respiration in animals. A man of average weight, says Professor Huxley, will take daily to maintain his condition 8,000 grains of chemically dry, solid matter, as food for his system; and no less than 10,000 grains of inhaled oxygen atoms, which certainly are not food, and which we can hardly doubt carry into the system the force which makes it alive and makes it work. Professor Huxley says that "the atoms which enter the body are, for the most part, piled up in large heaps, and tumble down into small heaps before they leave it," and that "the force which they set free in thus tumbling down is the source of the active powers of the organism." If he could say this of the 8,000 grains of daily food, he at least cannot say it of the 10,000 grains of oxygen. The oxygen atoms do not go in in piles, and do not do any tumbling down. And if ultimately they do a little knocking down of piles of food atoms, no amount of this could ever cause the motions which make protoplasm into living forms, and carry on in these forms the unceasing marvels of life. Oxidation in the living body is no more a cause of life than it is in the dead body. When Professor Huxley explains the function of oxygen in the living body by saying that "it is the great sweeper of the economy," and that it "gives rise to a temperature of about 100°," he no less says of oxygen in the dead body, "The sweeper of the living organism becomes the lord of the dead body." Oxidation is not life in one case, and death in the other. It is death in both cases, only in the living body the products of oxidation are carried away from the cells and thrown out, while the stream of inhaled oxygen atoms, beating into the blood corpuscles as they pass through the lungs, carried thence to every cell of the body, and beating with intense energy into every cell, make and maintain the vital state and vital motions.

It is not easy for imagination to grasp a clear view of the work of the oxygen atoms in the living body. When we have drawn air into the lungs, the oxygen atoms beat through the thin walls of the lung capillaries into the flying corpuscles of the blood. But they are passengers only in the corpuscles, and instantly that the corpuscles arrive in the tissue capillaries the oxygen atoms fly out through the walls of the capillaries into the cells of tissue. The blood corpuscles are going everywhere, and always the oxygen atoms are leaping out into the tissue cells. A single cubic inch of blood is said to contain 70,000,000,000 corpuscles, and the heart of a man, beating about seventy-five times a minute, drives out at each stroke from five to six cubic inches of blood from each ventricle, — thus making seventy-five trains per minute for oxygen atoms, each with not less than four hundred thousand million carriages. This rush of oxygen through every part of the body, and storm of the oxygen atoms into every tissue cell of the whole system, carries beyond all question the animating and vivifying energy which is the sole cause of the vital state and vital motion.

And this is the case with plants as well as with animals. Plants breathe to live quite as really as animals do, and have their vital state and vital motions from the energy of the oxygen atoms. One of our best authorities correctly says: "The true *respiration* of plants is very important, since it is always taking place in all living cells without exception; and the action of the inhaled oxygen is a necessary condition of the life of the protoplasm, and therefore of the plant. In relation to this the experimental fact is of the greatest importance, that plants placed in pure carbon dioxide are suffocated just as animals are." The contrast commonly alleged between plant life and animal does not exist. The real contrast is not in the way the two live, but in the use to which each puts its life. The plant, alive and active within cellulose bondage, on the soil and under the sun, makes inorganic matter into organic food-stuff, and lays it up. The animal, with a more refined protoplasm, not rooted in the soil nor related like the plant to the sun, cannot deal with inorganic matter as the plant can, but taking organic food-stuff and using it up it can reach a much higher form of activity, and have a much higher type of life, although the causes of life are the same to it as to the plant, and the only difference is the vastly augmented and elevated action of those causes.

It has been wholly a mistake to say that the sun makes the plant and the plant the animal, and that thus both plants and animals represent nothing but sun energy. The only special work done for the plant by the sun is that of feeding it with carbon, which the sun's rays do by beating off from the molecules of carbonic acid taken into the

plant the oxygen atoms; but while the sun's rays are thus driving away these oxygen atoms, others are beating into the protoplasm of every cell of the plant, and maintaining its vital state and motions. Both the plant and the animal represent, first and mainly, not sun energy, but oxygen energy. This intensely active substance, most imperfectly known as *oxygen* or "acid-maker," might be called *geogen* or "earth-maker," *ignigen* or "fire-maker," and *biogen* or "life-maker." The rock, the flame, the plant, the animal, are alike the children of oxygen. And oxygen is the maker of the earth, and of the forces and work of fire, and of both kingdoms of living things, wholly in consequence of the fact that the Cosmic Creative Cause has sent it on its mission of universal energy charged with that sole form of material force which we most imperfectly know as electricity.

It was a most just observation of Sir Humphry Davy, that "the silent and slow operation of electricity in the economy of nature is more important than its grand and impressive operation." In the action of the oxygen atom and its charge of electrical energy, as causes of animation in the protoplasm of plants and animals, we have an example of slow, silent, infinitely divided, perfectly ordered, and absolutely unfailing application of electricity to the finest, highest, and most varied forms of work.

The fitness of protoplasm for the action of the oxygen atom and its electricity consists first in its electrical state, opposite to the electrical state of the oxygen. The fact that the atom of oxygen acts across a dividing space, not being in contact with any atom of the protoplasm cell, or globule, or speck; and not only acts across a dividing space, but through a separating wall or film, by a leap right through this wall, ought to clearly suggest the electric charge of the atom, and that it has leaped into contact with matter of opposite electric charge. Four fifths of the air which we draw into our lungs consists of nitrogen atoms, and only one fifth oxygen. The nitrogen atoms go in only to come out again. They do not pass into the blood, and course through the body to all its parts. The oxygen atoms might equally go in and out, and nothing more. They find no door into the capillaries of the lungs, through which the blood is passing; they make no contact with the blood globules, because the delicate wall of the capillary prevents; yet, instead of turning back and coming out with the nitrogen atoms, they leap through the separating wall into the swift passing globules of blood. But only so many as are wanted by the globules leap in. If an animal breathes air which is *all* oxygen, it will still take only about so much into the blood. Usually the blood goes from the lungs about nine tenths full of oxygen, and returns about half full. The leap into the blood is only a beginning of the oxygen stroke. A

small part only of the oxygen charge is spent on that. The final and real stroke is when the blood globule comes to a tissue cell where oxygen is wanted; there the oxygen atom leaps with all its energy into the tissue cell, and gives up its energy, or a proportion of its energy, in the form of electrical currents through the protoplasm of the cell, with a slight result of animal heat, but chiefly with the result of electrical excitement and charge, which necessarily passes away directly, and would serve nothing if it were not incessantly kept up, but, being kept up, and entangled, divided, distributed, and just enough held by the protoplasm, does serve to make of wet dust a living creature, and to maintain with sureness and constancy the balance and the power of the vital state and vital motion.

The qualities of the protoplasm next after that of something in it electrically opposed to oxygen are those which enable it to entangle, detain, divide, and distribute the electricity given up by the oxygen atoms. And here we must understand that two facts are universal: the making of living things in one form or another, according to the protoplasm used in the beginning, giving a plant or an animal, and probably giving very many and very various origins in both kingdoms; and the making of all living things, all the way up the ascent of the creation, from the lowest result of the causes of life to the highest, wholly and solely through the response of protoplasm to the oxygen atoms and their electricity. The oxygen not only gives now the breath and energy of life, but it has blown plant and animal of every sort into their present form of structure and of working.

The speck of protoplasm has among its molecules some which insure the beating into it of the electrically charged oxygen atoms. Electrical action at once takes in hand the molecules of the speck, and sets that speck's house in order, with the result of making what our science calls a cell. Some of the molecules are pushed out to the outside and form a film called the wall of the cell. If suitable molecules are present this wall will be a shell, and there is nothing more certainly suggestive of an agent like the electricity of the oxygen atoms than the shells made for microscopic protoplasm specks at the lowest level of creation. Only such an agent could do the wonderful moving and placing of molecules which the microscope reveals to have been done in the making of these shells. And all was done, not on any purpose or plan, but simply as the result of electrical action sent among the molecules by the oxygen atoms. The flow of this action makes the cell wall by carrying to the outside of the speck certain of the molecules, the coarser and stickier ones apparently, or the harder ones. The finer ones are left to form the interior of the speck, and certain particular ones are gathered at one point into a nucleus, around which the electrical action in the speck centres.

Such a cell, with a cell wall and nucleus, is the unit of all living structure. All animals and all plants are entirely made up of such cells. When laid open to the microscope every living thing proves to be a mass of such cells; and life goes on by oxygen atoms incessantly beating into every cell in every living thing. Even the botanist has found, as we have already quoted, that "the true *respiration* of plants is always taking place in all living cells without exception." And as every plant and every animal is a mass of these protoplasm cells, so the functions and structure of plant and animal begin in the cell. The motions set up by the electricity of the oxygen atoms determine the functions and create the structure. In the lowest possible cell there are motions tending to a reproductive system, a nervous system, a digestive system, a circulatory system, and a muscular system. There is no function or feature which is not the direct and natural result of the motions set up in the protoplasm cell by electrical pulses which the oxygen atoms produce. Those molecules which are fitted for one or another place and use are carried to that place and put to that use, whatever it may be. Those which are fit and fine for the electrical agent to travel on are pulled into line for nerve, and will be bunched into ganglia and brain for special seats of the presence and action of the vivifying agent.

The function of nervous matter in the living body is immediately suspended by any check to the circulation of the oxygen bearing blood through it. And the amount of blood required by the brain shows how largely it is the seat of the force which the oxygen atoms bring into the system. The human brain is in weight about one thirty-sixth part of the body, but it takes one fifth of the blood of the system, seven times as much as the average. The pressure of electrical charge, carrying with it the molecules fitted to hold and to pass such charge, has made and maintains this body of nervous matter, the seat of sevenfold concentration of the force of the system. So nicely is the brain made and maintained as a seat of constantly entering and constantly passing away electrical charge, that if, through an opening in the skull, pressure is applied to the brain, disturbing the charge, letting it in fact pass off too fast, the activity of the organ ceases at once, and a state of profound sleep is induced, while awakening and renewed activity of the brain instantly result from the removal of the disturbing pressure. The true cause of the alternation of sleeping with waking is in the fact that, as soon as exertion and fatigue have created a state of the system at large, which requires in the cells an extra supply of the oxygen atoms, that supply will leave the brain on short allowance, the oxygen atoms always beating in where there is most call for them; and thus, when the cells of the body at large call

for an extra supply, the blood will go with too little to the brain, and so leave it to suspend full activity, until, when the body cells have made up their deficiency, the blood can again flow full laden with the atoms which bring the charge of life. The artificial sleep of mesmerism is produced by one or another method of reducing the normal electrical charge of the brain, and various remarkable phenomena come under the head of impressions electrically sent to the brain from without, not only from the brain of another person, but even from objects at a distance. As all space is electrically charged, a human brain may sometimes receive, across great distances, real impressions, its state and action as an electrical organ enabling it to do this.

The relation of nerve charge to muscular action affords the true explanation of the contraction of muscle. It explains nothing to say that muscle possesses contractility. We need to see something handling the molccules of the muscle, shifting the shape of its cells, so that now the muscle is longer, and now it is shorter, and yet the molecules and the cells strongly set and firmly held for either result, and freely changing from one to the other. The resources of electricity are so varied and inexhaustible as to fully meet the demand, and there is not the faintest chance of meeting it in any other way. In the lowest creatures we find remarkable phenomena of expansion and contraction. A mere cell of protoplasm, a liquid globule in a tiny sack, pushes out and draws in its cell wall, now merely bulging, now thrusting out, as it were, a foot or feeler, and now making a tail, thick or slender, and very often a hair-like lash. These lashes are called *cilia*, and they not only develop in the most remarkable way, but they lash about most astonishingly and with intense rapidity. All these forms are made and operated by the electrical pulses, or currents, or fast-flashing charges, which are set up in the protoplasm of the speck by the oxygen which beats into it. The curious cilia, which are made so finely and operated so swiftly, occur a great deal on the inner surfaces of animal structures, where they directly breathe oxygen and maintain their intense activity in the most wonderful way, — a way wholly inexplicable until we see how they are both made and operated by the electricity of the oxygen atoms. In the Protococcus, with its spores, each lashing about a pair of tails, while inside the parent globule, the tails are made and worked by the electrical action which is the life of the animated speck. A host of microscopic specks do a lively business in tails, and look like animals, when they are nothing more than vegetable specks, wet dust of plant protoplasm, blown into a touch of organic character and liveliness by the oxygen atoms setting up molecular whirlwinds in them. All structures in the protoplasmic state have a tendency, under the action of electrical production of life,

to reach out in the manner of a tail; and the occurrence of the tendency in any embryo is in itself no proof whatever of relation to tailed animals. Some confusion in biology would have been saved if inquiry about tails had begun where tails begin, at the lowest beginnings of creation, where we can see tails both made and unmade, run out and run in, and the finest and most finely operated tails, without the smallest reference to "descent," "slight variation," "geological time," "the struggle for existence," and "survival of the fittest." The oxygen atom, wiggling the tail of a swarmspore so fast that we can hardly see it, has had us in derision!

If we look at the other extreme of creation for the action of the electrical agent in the expansion and contraction of muscular tissue, we must remember that other aspect of electricity, our imperfect knowledge of which we veil under the term magnetism. One of our authorities says that "it has been shown by Ampère and Davy that an electric current has a tendency to *elongate* itself, but a magnetic 'axis of power' has a tendency to *shorten* itself." If then the molecules of a muscle cord are in the hands of an electrical current, the elongating tendency will be present, but if they are in the hands of magnetic influence, the shortening tendency will be present. We know that "the electrical and magnetic forces are so related that the one is exerted at right angles to the other." It is as if the molecules under the electrical current lay with their length in the direction of the muscle, and were magnetically forced about to lie with their length at right angles to the course of the muscle, and so to shorten the muscle. There is at least a hint here towards comprehension of the wonderful way in which force is applied in muscle. The facts already made out do not enable us to know how the varied play of electricity, now static and now current, now acting along the muscle and now across it, now with heightened charge and now with discharge, serves all the purposes of muscular activity, but enough has been observed to make imperative the assumption that this is the explanation. A fibre of muscle consists of a sheath filled with soft matter. The sheath has some strength; the soft matter has none. And yet this soft matter, and not the sheath, is the substance in and by which contraction is effected. It is wholly by means of electro-magnetic charge of this soft substance that it acts as it does. Just as magnetism sets together loose particles of iron, the molecules of the semi-fluid contractile matter inside a muscle fibre are set, by the magnetic effect among them of a current of electricity sent along the nerve. There is a *dead* set of these molecules after death, and a hard set of them in cramp. But in healthy life the play of electrical currents and magnetic action proceed with a balance none the less sure for being delicate and not open to detection. A body of mus-

cle consists of an immense number of sheathed fibrils of contractile protoplasm, and to every one goes blood to keep up its vital state, and nerve to carry the electrical impulse to magnetic action. The mass of countless delicate effects, in which the energy of the oxygen atoms manifests itself through nerve and muscle, gives us the large effect which we see. And we cannot too carefully remember that what the oxygen atoms have made the living system to be, the disposal which their electrical action has made, for nerve and muscle, and all other parts, is nature's only way of employing electricity for purposes of life. We are not to look for electricity as a property of muscle, an endowment or product of protoplasm. The animal system, and the plant in its degree and way, are receivers of electrical charge from the inhaled oxygen atoms, and the action of that charge, as it passes, and just while it passes, sets up the state and does the work of life.

We have extraordinary proof that the oxygen atoms do the work, and that their action makes as well as operates muscle and organ, in certain facts relating to the rhythmic action of the heart of an animal after death, especially that of a cold-blooded animal, together with the fact that the embryonic heart beats while its muscles are being made and when as yet it is only an amorphous mass of cells. One of our handbooks says: "The heart's rhythmic contraction is, under ordinary circumstances, sufficiently intelligible, and is what might be expected of any muscle under analogous conditions of regularly repeated stimulation. It is less easy to understand the apparently strange phenomenon of continuance of rhythmic action in a heart which has been removed from the body, — a phenomenon which, although lasting only for a minute or two in a warm-blooded animal, may continue for many hours in a cold-blooded, if the precautions as to temperature, moisture, and the presence of oxygen be observed." In these cases the life of the heart is kept up by oxygen atoms beating directly into it, the breath of life which it can take through its pores. The cold-blooded animals breathe a good deal in this way; hence the heart from one of them will much more easily respond to oxygen reaching it through its pores. The frog has peculiar ease in breathing through its pores, and a frog's heart will keep alive by breathing in this way for twelve hours. Experiment has shown that if the oxygen is cut off the action will cease, and if the oxygen is again supplied the action will be renewed. And in the embryonic heart, we can see the cause of motions at work, before the heart is made, the formless mass of cells beating rhythmically, when as yet the muscles, ganglia, and nerves, through which the work will be done ultimately, are not yet formed; showing that neither muscle nor nerve causes the beating, and that when muscular form, nerve connections, and ganglia are present

and playing their part, it is only that of structure which the pulses of the vital agent have made, and through which they work. It is not the constitution of the parts of the heart which causes the rhythmic movements, sixty or seventy times in a minute. The strokes of force were first, and made the heart with its parts, and to the causes of life the beating of the embryonic heart as an amorphous mass of cells may be simpler and easier than the beating of a muscular heart. It has been found that the younger an animal is the longer its heart will beat after death, under the influence of oxygen. It is because the younger heart is nearer the original protoplasmic condition in which motion is most easily set up. Life, as a period marked by physiological change, involves the gradual advance of the tissues of the organism from the protoplasmic state to that condition of obstruction to vital motion which at last either generally, or in some particular, stays the vital motions too much, or violently arrests them. The normal course of life is one of steady ascent from protoplasmic softness to the comparative hardness necessary to an effective body. In the earlier stage of growth the living creature is more susceptible than ever after to the entrance of the oxygen atoms and the setting up of electrical charge and play of electrical currents.

In the protoplasmic specks and minute living things at the lowest level of creation, we already see the play of force which later makes and operates the heart. Before there is any muscle, contraction takes place with an ease and rapidity which show that a swift play of material force is at work. Exhibiting one of the lowest animal forms, Professor H. J. Clark remarks: "Here is one instance, among many others, in which the muscular action of a scarcely organized body is as rapid as in the most highly perfected types of animals." Professor Clark also says of the long thread-like feelers or pseudopodia thrust out by another of the lowest and most minute animal forms: "The pseudopodia are exceedingly transparent, pointed, and so excessively slender toward their tips that it requires the best powers of the microscope to see them; but yet, upon the least disturbance, these frail threads retract their length down to almost nothing, with a lightning-like rapidity; even while you are looking at them there is a sudden shock, and they are gone." The explanation of this is seen at once if we refer the life and liveliness of the creature to the electrical charge from the oxygen atoms. Professor Tyndall exclaims against the view that bacteria darting about like lightning are not animal but plant specks. But in fact they do not dart about any more than dust whirled by the wind. They are darted about, and their life is only liveliness. Plant dust in water becomes subject to this electrical dance led by the oxygen atoms. Protoplasm specks from decaying

muscle were found by Professor Clark receiving life in the same way. The swimming done by ciliated specks, plant or animal, is done for them by electrical whirlwinds blown into them from the oxygen atoms. All sorts of pseudopodia are blown, to collapse when the charge within them escapes. Tails are pushed out and drawn in. The most exquisite microscopic shells are woven and shaped with a handling of molecules possible only to the electrical fingers of the oxygen atom. More wonderful still, long, needle-like, delicate spicula of silica are run out from animal forms, to show how fine is nature's mastery of material and force.

But before any of these things are done, in almost the lowest protoplasm specks, of plant or animal, we may see the pulses of electrical force, as they gather in charge and break in discharge, causing the pulsation of a space, bubble-like, but filled with water, not air, called the "contractile vacuole." The denser matter is driven outwards, leaving this watery centre, and then suddenly the sides of this centre collapse, entirely obliterating the vacuole. Back and forth the movement goes at regular intervals. It is the oxygen atom in its earliest attempt to blow the electrical breath of life into protoplasm. Professor Huxley says: "The function of these organs is entirely unknown." In fact, there is as yet neither function nor organ, nothing for the vacuole to do, and nothing to do it with. There are no walls to the vacuole when it appears, and with the return pulse it quite ceases to be. Half the time there is no vacuole. It is now there and now gone; a fleeting accident, yet the herald of creation. The oxygen atom has just begun to throw the electrical shuttle through the protoplasm, the play of which, as the ages of creation pass, will weave muscle, fashion the heart, draw out arteries and veins, set the lungs in their place, mould the countless globules of the blood, and send the whole pulsing stream on its course.

An absolute imperative is laid upon the true naturalist to look to the oxygen atoms and their charge of force as alone making all parts of every living thing. The causes of life must involve matter and force. Every living thing lives by a wind of oxygen atoms blowing unceasingly into it. At the stroke of this wind we find a flow of force handling molecules as only electricity and magnetism can handle them. If there is a conclusion which the present state of our knowledge puts beyond question, it is the agency of the oxygen atoms and their charge of electrical force in the maintenance of the vital state and vital motions in everything that lives and moves and has active being. The same force that sets the molecules of the crystal in their place finds in protoplasm scope for a free handling of free molecules; and with one sort of protoplasm it has built the world of plants, and

with another sort the world of animals. By the agency of the electrically charged oxygen atoms, the INSCRUTABLE CAUSE behind matter and force has blown the breath of life into two kingdoms of wet dust, not a little at first to give them a start and let them go, but from the first unceasingly and increasingly, carrying these kingdoms onward and upward by the continued and ascending energy of creative breath, setting all functions at work, making all forms, disposing the parts of structure, giving organs their shape and place and task, and finally, when all is made, making all to go, so that the making and the maintenance of all are alike the direct and instant result of those causes which received in the beginning the inscrutable commission of creation.

If we take the highest animal form, or all the forms of this highest kingdom, we can in one way, and in one only, trace the history of creation and the system of functions and organs, by following the play of electrical force among the molecules to see what the results of that play have been, — results as natural as the lines which the waves leave on a beach. The waves of electrical force have, by their natural flow, separated some molecules to shell or bone, some to muscle, some to nerve, and some to blood; and as these waves have gone on beating through generations of creatures, they have distributed functions and thrown organs into shape. Nothing has been done on a devised plan or for a particular purpose, but everything as simple and necessary natural result. The cell, which is the unit of all structure, is the protoplasm bubble electrically blown and animated and organized by the oxygen atom. The several functions of the living system are the several results of the play of electrical force through the mass of animated cells. The organs have taken shape in connection with the functions, first the function at work and then the organ. The curious taking in of food by the lowest living forms is as much by electrical attraction as when two pith balls kiss each other. The living speck and the food speck are driven together. Electricity feeds its offspring until they learn to feed themselves. Then the electrical stir in the protoplasm takes hold of the molecules of the food speck, digests any suitable ones into the protoplasm, and casts out the others. Thus a digestive function and a digestive system are started. As the function goes on and grows from more to more, methods are established, and organs gradually created. The digestion of food was first, and then a stomach formed about the digestive centre. The action of the function provokes the animating force to circle round it, to wait upon it, to give it help, until this surrounding aid of the system has become an organ within which the function is exercised. First the simple and naked function as a centre; then the surrounding concurrence of the system with the function; and then an organ giving structural form

to that concurrence. The electrical handling of all the matter concerned makes the working of the function and the creation of the form, where we have protoplasm in which to work and oxygen atoms to supply the electricity, at once sure and easy. The stomach came directly that it was wanted. The trains of molecules winding about to get out as excretion followed at first a mere course, then a channel, and then a channel with walls. The watery excretion, taking a separate course, had in time its own organs. Digestion and distribution of food have never ceased to be done by electricity. The much more than chemical force evolved is electrical. As soon as the food speck touches the living speck the electricity of the latter attacks the food molecules. And in coming to this attack the electrical force has made an organ to receive the food on and to do a little of what the stomach will fully do. Hence now the touch of food upon the tongue causes the instant discharge by this organ of an electrically charged fluid, the action of which is digestive. The jaws and the teeth have been produced in aid of the motions with which food was taken in. The existence of these motions determined here the formation of jaw and tooth structure.

But most direct of all results of the inflow of oxygen atoms has been the formation of the blood and the establishment of its circulation. Our authorities tell us that oxygen enters the blood globules attracted by one of their constituents, which is called hæmoglobin, and that it quits the blood globules, sooner or later, on account of greater attraction for the matter in the tissue cells. In the beginning, then, as the oxygen atom entered the protoplasm speck, it would first alight on the hæmoglobin molecule, rush it along with it, and ride on it, until, leaping off at the point of final attraction, it would leave the hæmoglobin molecule to make its way back to its natural post at the outside of the speck, dragging with it or some way taking along and casting out of the speck a molecule of carbonic acid. While thus acting as post-horse to the oxygen atom and drag-horse on the return to the carbonic acid molecule, the hæmoglobin molecule would become a centre of organic tendency, or of the play of certain molecules about it, the result of which would be the formation about the hæmoglobin molecule of a globule carriage, in which the hæmoglobin would ride post to carry in oxygen and to bring out carbonic acid. A train of hæmoglobin molecules would make a train of globules, and a system of trains would result from the leaping and flying oxygen atoms. For these trains there would be natural courses, and these courses would in a natural way become a system of channels, to which would form walls, until organic circulation were established, — the beginning of arteries and veins and capillaries. The action and reaction of the

oxygen atoms and the system would create the rhythmical pulsations of the flowing blood, and these would provoke the matter through which the blood channels passed to gather about the flowing streams in various organic ways and structural forms, of capillaries, and veins, and arteries, and the heart itself. The electric and magnetic spinning and weaving would absolutely respond at every minutest point, and to every least particular, of incitement, giving any amount and any complexity of structural formation naturally wanted. A tendency to a function sets up a tendency to a structure, and the two play upon each other until function and structure are both established. It may be motions within motions and wheels within wheels, to any possible extent, yet the force which has a commission to handle the molecules will never fail to find the way and to create the form required. The tide of force sent into the system by the oxygen atoms sets in motion a current which grows to be that of the blood; the force filling the system acts about and acts with this current, until it creates every needed form of structural cooperation with it. The heart is such a form of structural cooperation of the system with the established circulation of oxygen-bearing blood. Valves in the veins are the response of the system to reflux of the blood. The ray of sunlight teases the electrical state of the sightless creature, and causes motions about what we may call the centre of penetration of the ray, until the result is, a spot in the epidermic layer is made a lens, and an eye is created; not, indeed, all at once, but a tendency in one generation, a touch of organic effect in another, and soon the completed work. The ear comes by the hearing which, without an organ, the living creature will sooner or later begin to do. Everywhere function results from the electrical state of the living system, and the action of function with the cooperation of its environment creates the needed organ.

The final function of the living system is that of reproduction, and the finest creative work done is that of making the germs by which reproduction takes place. These germs are in effect reproductive patterns, and beyond all question they are this in fact. The ovule and the pollen grain of the plant, the ovum and spermatozoon, are protoplasmic reproductive patterns. The proof of this is absolute, if we but hold our thought to the facts. And to nature it is not difficult to do by pollen grain and ovule, by ovum and spermatozoon, the double work, now of exact reproduction, and now of reproduction with specific variation, giving in the one case descent, and in the other the origin of species. The material law for all reproduction is, that in every living thing whatever one system of motions and one selection and placing of molecules proceeds by way of a reaction of the whole system, in its form and in its features, against the entire stir of force

within it, with the result of producing, at a focus of this reaction, a molecular pattern, or any number of patterns, of the parent form, which have only to live and grow for themselves to reproduce that form, and which do in fact live and grow for themselves a little as soon as they exist, and commonly are a little developed before we make their acquaintance. The focus of the motions which create reproductive germs may turn out successive products which are moved away from it, or it may move, or it may exist in multiple, as in some of the lowest forms; for no limit can be placed upon the infinitesimally divided, slow, ceaseless, sure play of the protoplasmic electricity. And in making reproductive patterns, it works by means so far within the profound realm of molecular refinement that none of the result depends, as anatomists were at one time disposed to think, upon the organic aggregation of the reproductive molecules in an invisible embryo. The invisible embryo is not there, but molecules electrically commissioned by the parent organism to make it are there, — molecules electrically stamped for reproducing the parent organism; and when the conditions of growth for the germ are met, these molecules will execute their commission with absolute truth and sureness. In any smallest of germs there are millions of the molecules, and that refinement of the electrical force which corresponds to them holds them ready to do each their appointed part. Not one pollen grain, not one ovule, not one spermatozoon, not one ovum, but has been made to be, and will do the work of, an exact reproductive pattern. We find the parent form and features carried through the germ produced by that form, and we are bound to hold our thought to the fact that the germ carries it. It is as true for pollen grains and spermatozoa as for ovules and ova, although only the very latest authorities have at last made it out. When we see a new lily produced, uniting the form of a giant lily with the flower of the Japan lily, are we to believe that the ovule carried its contribution of structure, and that the other half of the double structure got in somehow without being carried by the pollen grain? The only belief at all scientific is that pollen grain and ovule serve exactly the same purpose, and are equally reproductive patterns. The animal spermatozoon has had no really scientific recognition, until just now it is found to be, not a mere "element," "influence," "nutriment," mysteriously necessary to the ovum, but the structural and material equal of the ovum, destined to conjugation with it. And no other conception is open to us except that of its action as a reproductive pattern. Any germ, male or female, is structurally sufficient for reproduction, if only growth would set in without the union of two opposite germs, and in fact it does set in, in some cases. Not only that, the function of reproduction proceeds at first without

any germ at all. In the simplest case, the motions tending to reproduction of the parent form act on the whole form and break it up, into a few forms it may be, or into a myriad of young forms. With a perfectly free state of the protoplasm of a structure, this is the tendency. In another state of the protoplasm, as soon as a focus of reproductive action is established, there may be set up a process which will throw this centre off as a bud. It is the third form of reproductive action which gives ova and spermatozoa, and this form appears as soon as structural tendencies become fairly developed.

In the earlier stage of the process of development there is more or less tendency of some germs to develop singly, instead of by pairs. But this is not strictly the absence of sex. Every germ whatever is of both sexes, and every living thing is of both, the male or female individuality consisting only in a predominance of one side, and structural development of that side, relatively but not wholly suppressing the opposite side. There must be for the distinction of the two sides a ground in a law affecting matter as matter, and that law is the opposition of the two phases of electricity in nature. A number of facts could be cited in proof of the statement that male and female are of opposite electricities, and that sexual distinction had its origin in electrical separation. The electricity of the oxygen atom is characteristic of the male, and that of protoplasm of the female. But in any form of protoplasm, the electrical excitement of life would produce a degree of electrical separation, the simplest result of which is seen in the earliest of all distinctions set up, that of the mucous character of the exterior part, and the serous character of the interior part, of the protoplasm speck; which in germs becomes "the serous and mucous layers of the germ" (Huxley), and which in structural development emerges in ectoderm and endoderm, or epiblast and hypoblast, corresponding to male and female, and naturally coming together in the formation of the mesoblast, which gives the middle unity of the living system. In the life of a motile swarmspore at the lowest level of creation, we can see the earliest indication of sex accompanying the earliest action of the causes of life. Sachs says of the swarmspore, after it has escaped from the mother cell: —

"The naked swarmspore moves with a rotary, and at the same time progressive, motion for some minutes, hours, or even days, until it finally comes to rest, becomes fixed to one spot, and germinates. In every swarmspore there may be distinguished an anterior hyaline end, usually pointed, which is turned foremost during movement, and a posterior, thicker rounded end, provided with chlorophyll. The line which unites the two ends is the axis of growth of the swarmspore and of the embryo plant which grows from it. When the

swarmspore comes to rest, it fixes itself by its anterior hyaline end, and forms there a hyaline organ of attachment, which is often branched; while the colored posterior end becomes the free apex of the young plant. The rotating, advancing movement is occasioned by cilia, fine vibratile threads, which are sometimes very numerous, but short, and cover the whole surface of the swarmspore, while sometimes they form a crest round the hyaline part, but are most often fixed in pairs to the anterior margin, and are then very long. Sometimes swarmspores are of two sizes, indicating, perhaps, a sexual relationship as yet undemonstrated."

The results of able observation give us no finer first page in the history of creation than this, if we know how to interpret the observed phenomena. The seemingly inexplicable animal-like motion is not what it seems; it is entirely the effect of electrical action set up from without by the oxygen atoms, — as it were, an electrical wind blowing through the spore. The currents of this electrical action create and operate the cilia of the spore. Electrical separation creates an axis and poles of the spore, the distinction destined to emerge structurally in sex. The hyaline pole of the spore is male, and the thicker rounded end female. In the two sizes of spores there has begun a separation into male and female individuals, the smaller showing male tendency to preponderance, and the latter female. The one electricity always uses smaller molecules, and makes a smaller body, for the male side, yet not less intense and potent, but rather more so. The pollen grain and the spermatozoon show their character less, but they possess it no less, and are no less structurally potential. The ovum can grow alone sometimes, when the spermatozoon cannot, because the oxygen atom itself is male to it, and because it already has a male part. An ovum not too far from simple protoplasm will grow alone. A spermatozoon could, if its electricity were not too near that of the oxygen atom. It must be considered that electricity is relative. The spermatozoon is positive as a whole, and the ovum negative, although within the spermatozoon the head and structurally substantial part is negative to the opposite hyaline and ciliated part. When spermatozoon and ovum unite, each begins by casting off its positive or male part, so that structurally each is an ovum, and each might be conceived as a bud or germinal pattern of its parent. In every case of such union of two germinal bodies, the growth which follows involves the development of two structures as one, the two uniting in the protoplasmic state wherever union is necessary to one life, yet conspicuously separating in many features of structure, which thus appear double in each individual, or single by a manifest junction on a median line. Except some of the lower types, every body

of plant or animal is two, welded by protoplasmic junction into one, from the union upwards of two reproductive patterns. However the inweaving together may proceed, each form is two forms woven into one. Probably every part is thus doubly woven, but with more or less tendency in different parts for one of the reproductive structures to preponderate, and thus manifest the characteristics contributed by it. This preponderance of one half of the double structure is particularly worked out in the structural establishment of sex, which takes place by the development of one set of characters and the suppression of the other. As this is decisively promoted by the maintenance, never lost, of electrical opposition between the two sets, we readily see that it has always been a law, and that nature was never hermaphrodite above a low level of creation. The signs construed as descent from hermaphrodite forms are signs that nature, being double, yet refuses to be hermaphrodite. But it is only because of the opposing electricities. Nature has no "purposes," but only flows on as the stream of material law determines. The abstinence of plants from self-fertilization is not on purpose, but is simply due to the fact that pollen grain and ovule on the same plant are in a state of low electrical opposition, compared with a pollen grain from one plant and an ovule upon another. And no doubt, as insects are highly electrical, the pollen grain carried to an ovule by an insect has its function heightened thereby.

It is not, however, the case that plants have been somehow modified to fit the insects, in order that the insects may serve them. The true origin of species is not in this way. A correct view of the causes of life, and of the working of these causes to make and to use reproductive patterns, discovers to us the true origin of variations and the true origin of species, upon a plan quite unlike the Darwinian. It is when the environment presses in any way upon a parent organism, and creates a tendency or need to vary, that the law of the origin of variations and species comes into play. That law is that a need or tendency to vary felt by a parent organism creates a variation in the reproductive pattern, and thus establishes in the offspring what was only a tendency in the parent. A mere spot in the epidermis, concentrating the electrical effect, in an animal, of sunlight upon it, might borrow geological time forever without becoming an eye, but when the stress of tendency descends into the protoplasmic germ it easily creates a touch of new character, which the same process will in a very few generations make a complete creation. Insects upon flowers constitute a peculiarly decisive pressure of environment, not only their weight but their electrical intensity contributing an interference which the reproductive patterns of the plant will respond to, and by which

specific changes will become established both surely and rapidly. The plants have not been somehow varied, and then, by fitting the insects, favored in a struggle for life, but they have been varied directly, solely, and rapidly by the insects, the pressure of which, though inoperative upon the plant itself, has been easily and quickly operative in the reproductive germs of the plant. Interference with the creative function of parentage has been the easy, sure, and quick means of originating variations, and by a course of variations creating species. As soon as two reproductive patterns become so unlike that they will not weave together into one structure, we have a species. In all probability parallel species in great number rose from the first origins of life, and in what may be called the ages of creation great numbers of species have come into existence side by side, through the individual character of the results of violent setting in motion of the influences of environment. Leibnitz said that nature does nothing *per saltum*. He was right enough for the commonplace course of nature, but creation in nature is always *per saltum*. The origin of species is like the winding up of a clock, by means of interference with descent, sometimes slight and slow, but sometimes swift and stupendous. If we can open the book of the ages at the places where the whole environment was in a state of the greatest change, we may be sure that living things had to respond, and, through the action of parent organisms upon reproductive germs, did respond, in strokes and leaps of creation which perhaps all at once set in motion many new lines of development. A few generations, in an age of sufficient pressure, from an environment in a state of revolution, would answer for changes which it has been supposed got place only through "thousands on thousands of generations."[1] The profound law under which forms can be modified and made over, by influences acting on the reproductive patterns through the parent organisms, gives a possibility of new creation sure to be worked out under the right conditions of the environment. Those conditions have come with the ages of change, of cataclysm, in the state of the globe. With overwhelming and peremptory pressure of the environment has come all at once those births of geological time, the bird from the reptile, and man from his non-human ancestor. The laws which Mr. Darwin names, in the closing paragraph of his work on the origin of species, as having accomplished everything, would have left the highest creatures to this hour the not much modified descendants of that "ancient progenitor which was furnished in its adult state with branchiæ, a swim-bladder, four simple limbs, and a long tail, all fitted for an aquatic life," simply because, with no law of natural creation, of profoundly making over a lower species into a

[1] Darwin.

higher, an ascending and conquering progress would have been impossible. If any long-tailed aquatic creature ever got out of the water, and became a creature of another sort, it was when, in some part of the globe, a grand cataclysm put the species out, with probably killing effect upon the great mass, but sparing some best prepared parents with seed, under such a pressure of entirely altered environment as naturally endowed their seed with a beginning of, and tendency towards, entirely altered character, by means of which the new births would be able to take to the new life, and under its environing pressure rapidly complete the evolution of the new species. It was by this vastly emphasized appeal to the law of creative parentage that Nature must have pushed her child up from a non-human to a human level.

At this level of the creation there comes into play an extremely high form of the law of creative parentage, that of creative motherhood, expressing the power over offspring of influences reaching the young through the mother. The effect of these influences when sustained and strong is of the highest creative character, whether for good or for evil. There is now a case in England of a man thrown back by his birth to non-human characteristics of person and mind, — of mind especially, so that he has to have a keeper, and of person to the extent that he has very distinctly the ape look and air. His mother was a lady of good position and mind, and her son's condition is due solely to the fact that he was born under the seal of the impression produced upon her by the intrusion of an ape. In the condition in which she was, the impression took an unrelaxing hold on her brain and mind, at the time when she could not but transmit it with the effect of a fatal seal, — an effect profoundly creative of the undoing of human development. In another case, a girl, now about grown to womanhood, was born drunk of parents who had never tasted liquor, — her gait, all her motions, and her speech following exactly the manner of a completely intoxicated person, although she was in both physical and mental habit sound and well, and was of a singularly sound, sober, and excellent parentage. It was the intrusion upon the mother, before the child's birth, of an intoxicated man which produced this result. The excessive fright left the impression of the drunken man upon the mother, so fastened and powerful that she could not fail to leave it on her unborn child. It is almost certain that this power of motherhood may give a charge, as it were, to the unborn young, not only affecting early characteristics, but affording a permanent source of development of character and power. Some of the most enduring and energetic men have inherited by mere descent weak and sickly forms, destined to become exceptionally strong, through the development of a charge of tendency that way, given by ardor of mother concern and mother in-

terest. Great and peculiar genius has no other secret than creative motherhood. I know a little girl, a prodigy of quickness with the piano and the organ from her earliest years, for whose gift there is no explanation except the fact that before her birth her mother, who could hardly play at all, yet constantly made attempts, of no value to her, but of creative fruitfulness for her child. In very many of the instances of highest significance, such as Shakespeare, Buddha, and others only less notable, the action of creative motherhood and its characteristic effects can be clearly traced, while in recent cases, where all the facts are accessible, the amplest proof can be given. Hence the reasons for confidence that it was by this hand of comparative, natural miracle that Nature pushed her creation up from the non-human to a human level. The creation of man upon a lower animal was effected by the utmost possible appeal to the law of creative parentage, especially that of creative motherhood. Had natural selection alone worked on even the very highest non-human creatures, it could never have changed the level of the race by that difference which was necessary to create man. It was only when, in some section of the globe, there came upon the highest non-human creatures a completely overwhelming change of environment, which put the race to the greatest effort to exist, and kept this pressure at the highest pitch through an age of revolution, that it became possible for superior and favored parents, amid the general sacrifice, it may be, of their race, to give birth to offspring decisively stamped with new characteristics and capable of development into creatures of a new kind, — a kind armed with capacity for stage on stage of human development, in proportion as favored environment should furnish the requisite conditions. In this way, and in this alone, might take place the natural creation of man. The non-human mothers of a lower race, put under extreme pressure to mental effort, would bear young endowed with a greatly advanced and rapidly ascending power of mind, and increase of both size and quality of brain, Nature thus forcing her creature upward, and the Intelligence which lies behind nature thus making, from a non-human creature, man in its own image. By means of a law profoundly creative Nature pushed her non-human creature up the vast ascent to man, putting that creature under the extremest pressure of external environment, and powerfully forcing mental effort, until by creative motherhood had been effected a most vigorous and complete evolution and endowment of brain, and a reaction of the new brain and mind and life against the non-human bodily characteristics, the end of which was the human quality of person and life. If the rigor with which the pressure of environing influences was exerted was such as to permit only the best births to survive, we can readily see that the